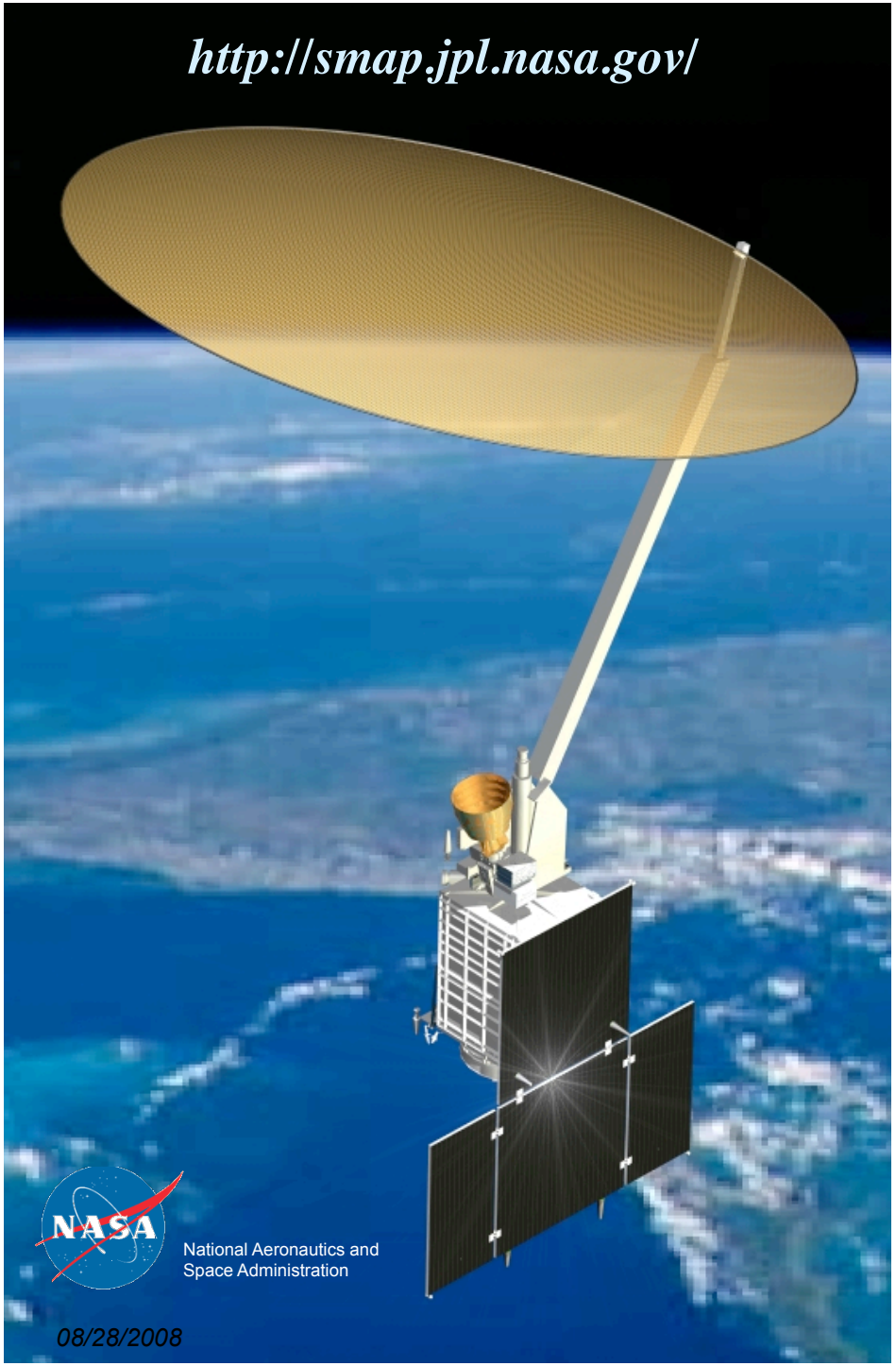



# *Soil Moisture Active and Passive (SMAP) Mission*

## *Decadal Survey Workshop*

*February 11, 2009*

*For planning and discussion purposes only.*

National Aeronautics and Space Administration

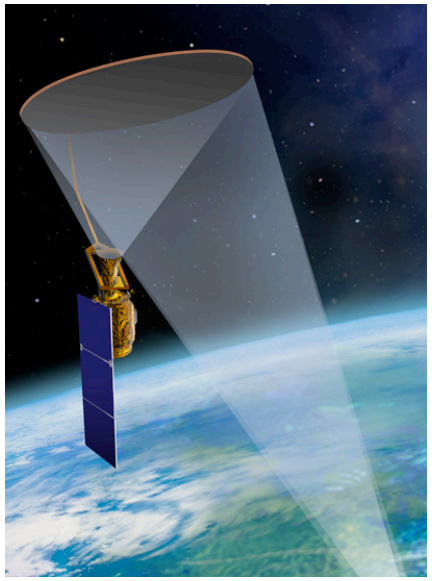
*Soil Moisture Active-Passive*

# SMAP Mission Quad Chart

## Primary Science Objectives

- Global, high-resolution mapping of soil moisture and its freeze/thaw state to:
  - *Link terrestrial water, energy and carbon cycle processes*
  - *Estimate global water and energy fluxes at the land surface*
  - *Quantify net carbon flux in boreal landscapes*
  - *Extend weather and climate forecast skill*
  - *Develop improved flood and drought prediction capability*

## Mission Approach



- GSFC L-band radiometer provides high accuracy, moderate resolution
- JPL L-band radar provides high resolution and freeze-thaw detection
- Common 6m antenna spins at 15 rpm to provide global coverage in 3 days
- Merged radiometer & radar data yield high accuracy, high resolution soil moisture product
- 670 km polar sun-synchronous orbit

## Development Status

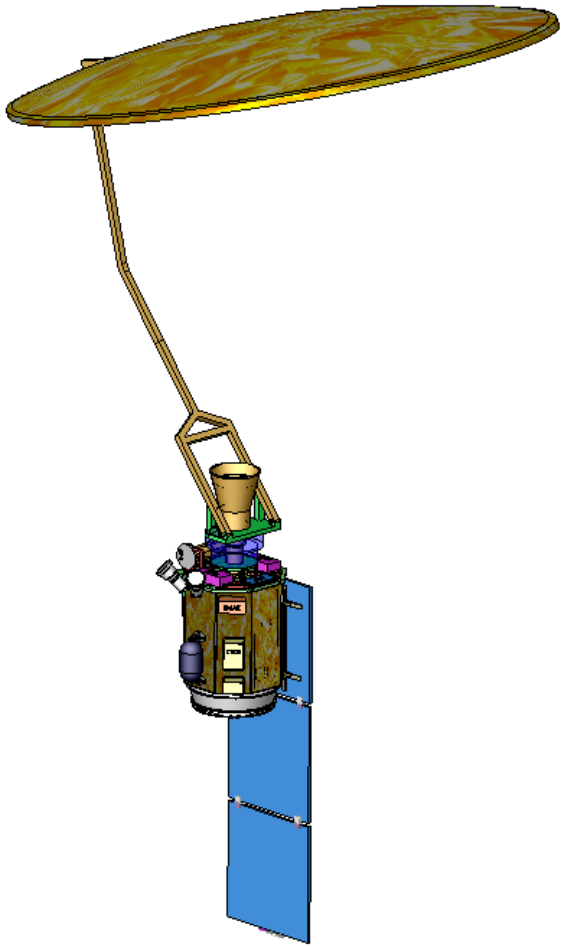
- SMAP entered Phase A in September 2008
- Science Definition Team selected; initial SDT meeting held in Nov 2008
- Conducted initial airborne campaign to evaluate algorithms and RFI susceptibility
- Now completing key mission trade studies; requirements definition & flow down for MDR
- Completed ASM Meeting with NASA HQ

## FY09 & FY10 Development Objectives

- Complete MDR/SRR/PNAR (Feb '09)
- Transition to Phase B (May '09)
- Launch Vehicle Selection (June '09)
- Complete PDR (January '10)
- Transition to Phase C (March '10)

# Anticipated Returns

Soil Moisture Active and Passive (SMAP) Mission



**Science Return:** SMAP Will Deliver Global Views of Terrestrial Water Cycle State Variable: Soil Moisture Content and Its Freeze/Thaw State

Soil Moisture is a Variable That Links the Global Water, Energy, and Carbon Cycles

**Applications Return:** SMAP Will Bring a New Capability to Predict Costly Natural Hazards (Extreme Weather, Floods, Droughts)

Initialization of the Soil Moisture State in Numerical Models Extends the Predictability of Processes Influenced by Surface Fluxes

**National Defense Return:** SMAP Global All-Weather Mapping Supports Battlespace Decision-Making and Force-Enhancement

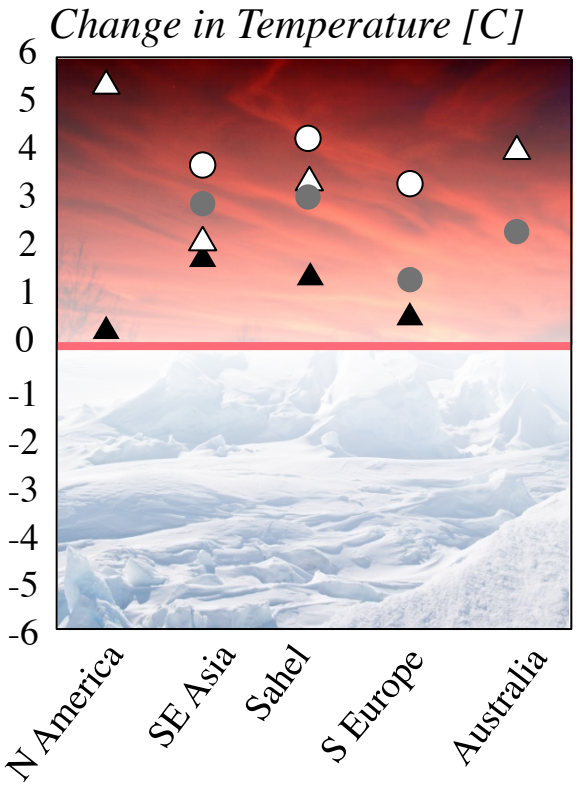
| | |
|---|---|
| Air Force | NWP and Aviation Weather |
| Army | Terrain Trafficability |
| Navy | Sea-Ice Edge and Age Assessment |

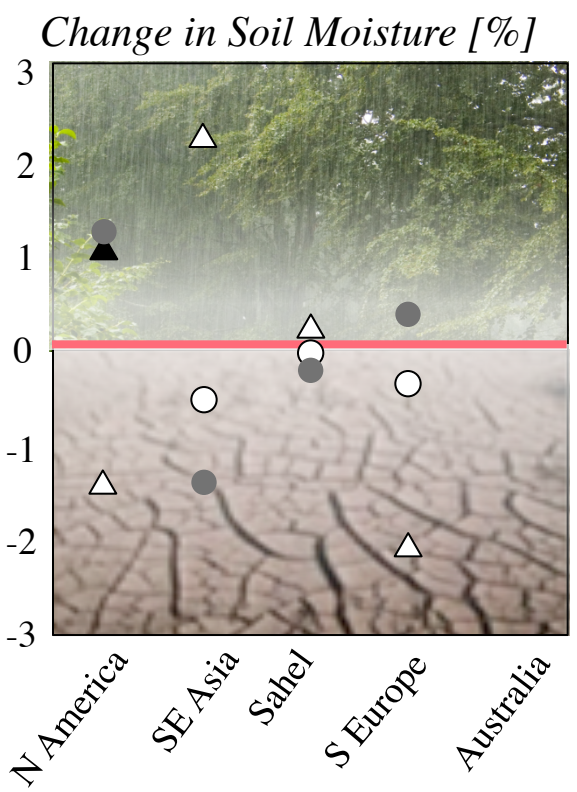
# SMAP Data Will Enable Reliable Estimates of Changes to Future Water Availability

**Change in water availability is a critical practical impact of global warming on society. How will global change affect water supply and food production?**

Intergovernmental Panel on Climate Change (IPCC) climate model projections by region:

**Models *agree* on direction of temperature increase**




**Models *disagree* on whether there will be MORE or LESS water compared to today**

**Without SMAP data we cannot tell which hydrology models are accurate. With SMAP data we will be able to make reliable determination of future changes in available water.**

Li et al., (2007): Evaluation of IPCC AR4 soil moisture simulations for the second half of the twentieth century, *Journal of Geophysical Research*, 112

# Project Status

- Project entered Phase A on September 24, 2008
  - Mission Concept Review was conducted on June 24, 2008
- Science Definition Team was selected in Oct 2008
  - First SDT held November 12 & 13, 2008; reached agreement on L1 requirements recommendations to NASA
- Project is making good progress on key Phase A trade studies and requirements and system interface definition as appropriate for MDR
- Project has staffed all top leadership positions and is meeting its staff up plan
- Working groups formed with GSFC/GN and GSFC EDOS organizations to develop Project interfaces and support agreements
- NASA/KSC has completed their study of available launch services under the existing NLS contract
  - DoD subsequently announced they will provide a launch vehicle for SMAP based on high SERB ranking (6 of 62); discussions with NASA are pending
- Completed an Acquisition Strategy Meeting with NASA HQ

# Community Outreach & Involvement

- SMAP has a public website (see coverage page for this briefing for URL)
- SDT members have provided public briefings on SMAP (e.g., Museum Alliance)
- SMAP science leadership have engaged operational applications communities
  - NOAA NCEP/NWP & NWS Office of Hydrology Development, ECMWF, AFWA have expressed specific and strong interest in using SMAP data
  - NOAA has established a SMAP working team & high-priority study topics
- SDT and Project science are proactive at major int'l conferences, workshops and meetings; use these to garner collaborative support for the mission (cal-val, etc)
  - CiCAT, CC&E, SPIE/ERS, COSMOS, NEWS, SMOS SAG, AMSR-E, NAFE
- SMAP held an Open Meeting at IGARSS, July '08; 50 people attended
- SMAP was well represented at the October Hydrology Workshop
- SMAP SDT Working Groups areestablished Applications, RFI, Algorithms, Cal/Val; informal meetings were held at AGU
- Future planned SMAP-related workshops, e.g., on Cal/Val (June 2009).

# FY08/FY09 Results

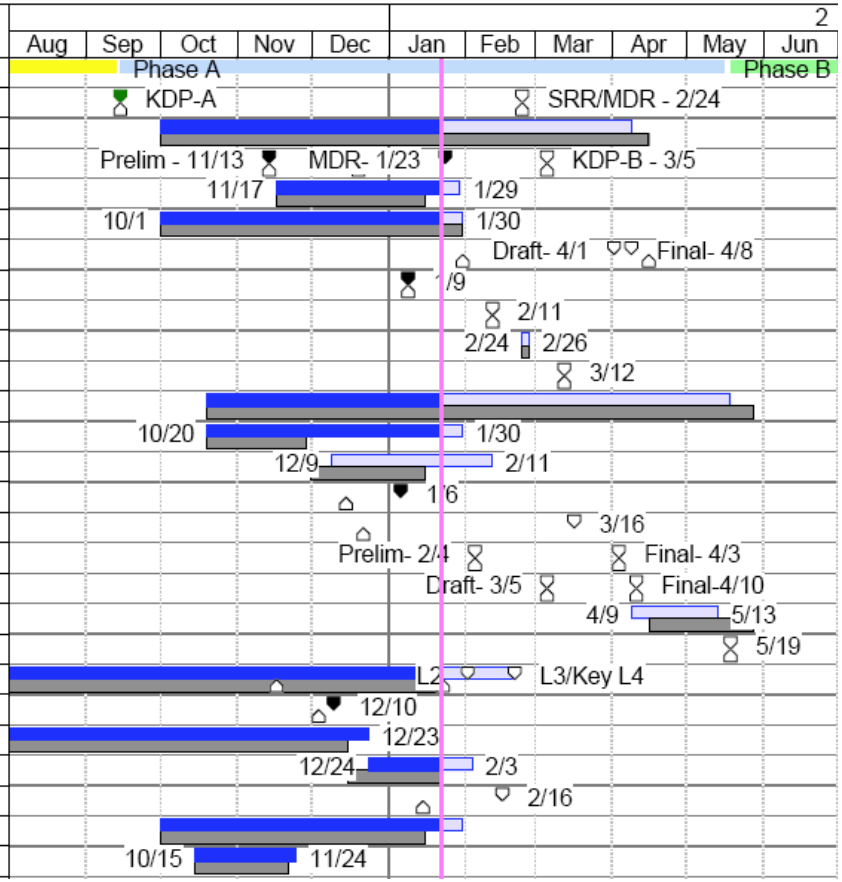
- Confirmed Hydros architecture is optimal for required science observations
- Completed KDP-A and officially entered Phase A
- Completed SDT and Project review of earlier draft L1 requirements document
  - Project formally submitted joint recommendation on L1 updates (minor changes) to ESM and NASA HQ
- Identified and assessed potential international contributions (CSA and JAXA)
- Concluded major flight system architecture trades (spinner vs three-axis stabilized, navigation/orbit determination approach, data volume accommodation, flight system redundancy and reliability features)
- Initiated dynamics team, developed initial flight system dynamics and pointing model
- SDT completed an RFI risk assessment and has formally recommended to Project to incorporate additional risk mitigation features

# FY09 Plan to Go

- Complete Phase A
  - Approve L1 requirements
  - Flow requirements to key and driving L3 and L4
  - Develop spacecraft architecture and instrument interfaces/accommodations
  - Complete draft Algorithm Theoretical Basis Documents (ATBDs) and begin algorithm evaluation; prepare algorithm testbed
  - Generate Phase B plan and update mission lifecycle cost
  - Complete Mission Definition Review (February) and KDP-B (May)
- Initiate Phase B preliminary design
  - Key concern is launch vehicle selection early in Phase B to support environment and interface definition and initial coupled loads analysis
  - Initiate Phase B preliminary design and risk reduction activities

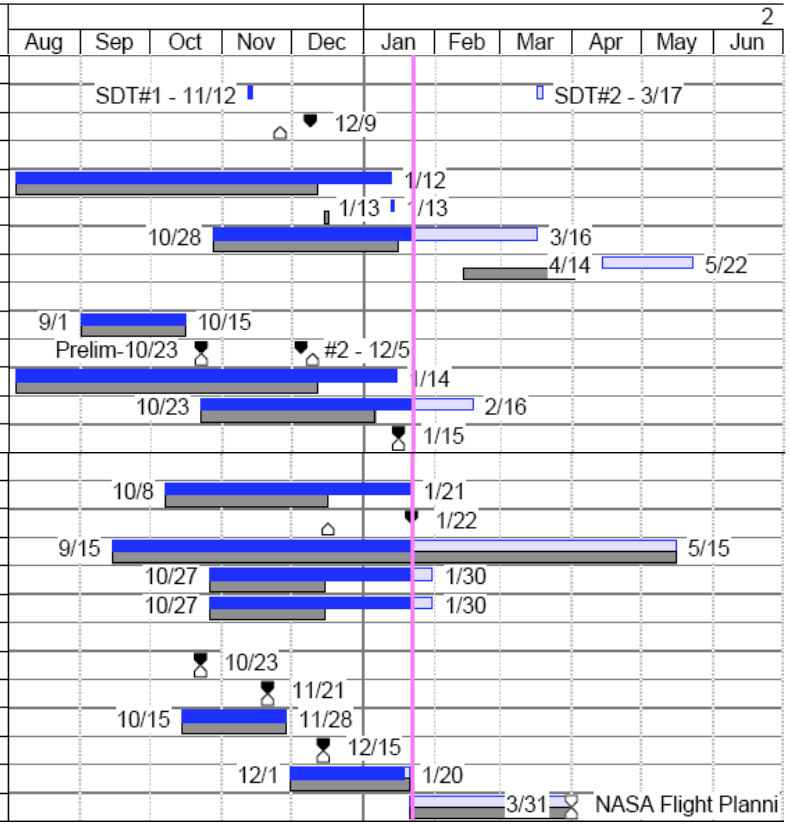
# Phase A Activities are On Plan (1/2)

| ID | CAM | Task Name | Start | Finish |
|---|---|---|---|---|
| 1 | | **SMAP Project Phases** | **5/6/08** | **3/18/16** |
| 8 | | **Key Milestones** | **9/15/08** | **2/24/09** |
| 11 | | **Project Management** | **10/1/08** | **4/8/09** |
| 12 | Eric Kwan | CADRe | 10/1/08 | 3/5/09 |
| 20 | Kellogg | Phase B and Project Lifecycle Planning | 11/17/08 | 1/29/09 |
| 21 | Kellogg | Project Plan (Prelim) | 10/1/08 | 1/30/09 |
| 22 | Kellogg | Task Plan | 1/26/09 | 4/8/09 |
| 27 | Kellogg | MDR Preliminary Agenda Defined | 1/9/09 | 1/9/09 |
| 29 | Kellogg | Del KDP-B Gate Products Delivered to SRB | 2/11/09 | 2/11/09 |
| 30 | Kellogg | SRR/MDR/PNAR | 2/24/09 | 2/26/09 |
| 31 | Kellogg | Project Review of Draft SRB Report and RFA Disposition | 3/12/09 | 3/12/09 |
| 32 | | **NASA/ESMPO/IPAO** | **10/20/08** | **5/19/09** |
| 33 | NASA HQ | Review & Approve KDP-B ToR | 10/20/08 | 1/30/09 |
| 34 | ESMPO | L1 Requirements Approval Process | 12/9/08 | 2/11/09 |
| 35 | NASA HQ | ASM | 1/6/09 | 1/6/09 |
| 36 | NASA HQ | Approve Spin Assy & Antenna RFP Releases | 3/16/09 | 3/16/09 |
| 37 | IPAO | Del ICE | 2/4/09 | 4/3/09 |
| 40 | Mark Goan | Deliver SRB Report | 3/5/09 | 4/10/09 |
| 43 | NASA HQ | Review and Approve Phase B Task Plan | 4/9/09 | 5/13/09 |
| 44 | NASA HQ | KDP-B DPMC | 5/19/09 | 5/19/09 |
| 45 | **Goodman** | **Project System Engineering** | **5/6/08** | **2/20/09** |
| 47 | Goodman | L1/2/3 Pre-MDR Req Rev | 12/10/08 | 12/10/08 |
| 48 | Goodman | ASM Trade Studies | 5/6/08 | 12/23/08 |
| 49 | Goodman | SRR/MDR Trade Studies | 12/24/08 | 2/3/09 |
| 50 | Goodman | Interface Requirements Document (Prelim) | 2/16/09 | 2/16/09 |
| 52 | **Plourde** | **Safety & Mission Assurance** | **10/1/08** | **1/30/09** |
| 53 | Plourde | Develop Class C Implementation Description | 10/15/08 | 11/24/08 |



# Phase A Activities Are On Plan (2/2)

| ID | CAM | Task Name | Start | Finish |
|---|---|---|---|---|
| 55 | **Njoku** | **Science** | **11/12/08** | **3/18/09** |
| 56 | Njoku | Science Definition Team (SDT) | 11/12/08 | 3/18/09 |
| 59 | Njoku | SDT-Endorsed L1 Science Req | 12/9/08 | 12/9/08 |
| 60 | **Edelstein** | **Instrument System** | **8/4/08** | **5/22/09** |
| 61 | Edelstein | Inst L3/L4 Requirements Development | 8/4/08 | 1/12/09 |
| 62 | Edelstein | L3/4 Pre-MDR Inst Req Review Meeting | 1/13/09 | 1/13/09 |
| 63 | Edelstein | Inst Spin Assy and Antenna RFPs Development | 10/28/08 | 3/16/09 |
| 64 | Edelstein | Inst Spin Assy and Antenna Source Sel & Down Sel | 4/14/09 | 5/22/09 |
| 65 | **Thurman** | **Spacecraft** | **8/4/08** | **2/16/09** |
| 66 | Thurman | Dual Spin / Three Axis Bus Trade Studies | 9/1/08 | 10/15/08 |
| 67 | Thurman | FS Arch Peer Reviews | 10/23/08 | 12/5/08 |
| 70 | Thurman | Spacecraft L3/L4 Requirements Development | 8/4/08 | 1/14/09 |
| 71 | Thurman | S/C Subsystem Studies/Req & Interface Doc. | 10/23/08 | 2/16/09 |
| 73 | Thurman | S/C L3/L4 Requirements Review | 1/15/09 | 1/15/09 |
| 74 | **Gunter** | **Mission Operations System/SDS** | **9/15/08** | **5/15/09** |
| 76 | Gunter | SDS L3/L4 Requirements Development | 10/8/08 | 1/21/09 |
| 77 | Gunter | L3/4 S/C MOS/GDS/SDS Pre-MDR Req Rev | 1/22/09 | 1/22/09 |
| 78 | Gunter | Develop Prototype Science Algorithm Testbed | 9/15/08 | 5/15/09 |
| 79 | Gunter | Develop PSLA with GN/SN (Draft) | 10/27/08 | 1/30/09 |
| 80 | Gunter | Develop Agreement with EDOS (Draft) | 10/27/08 | 1/30/09 |
| 81 | **NASA** | **Launch System (NASA)** | **10/15/08** | **3/31/09** |
| 82 | DoD | DoD SERB Meeting | 10/23/08 | 10/23/08 |
| 83 | DoD | DoD SERB Results | 11/21/08 | 11/21/08 |
| 84 | NASA/KSC | Launch Veh. Study | 10/15/08 | 11/28/08 |
| 85 | NASA/KSC | SMD Briefing | 12/15/08 | 12/15/08 |
| 86 | NASA | SMD launch Vehicle Approval Process | 12/1/08 | 1/20/09 |
| 87 | **NASA** | SOMD Approval | 1/21/09 | 3/31/09 |



# Issues & Questions (1/3)

- SMAP has no technology readiness issues
- **SMAP Issue:** SMAP needs to resolve launch vehicle choice early in Phase B to define LV environments, interfaces, initiate coupled loads analyses, or risks a cost impact for carrying multiple launch vehicle options later into development
  - There is a significant gap in launch service capability and cost within NLS inventory between the Taurus- and EELV-class vehicles; vehicles now in development (Taurus II, Falcon-9) may improve situation but availability to NASA is uncertain
- **ESM Question:** What is the appropriate Project-funded balance between science and applications needs (how far should Project's go funding-wise to support operational and applications communities)?
  - A key topic for SMAP has been data latency requirements for science vs operational community wishes
  - A possible future question may be special products/capabilities for operational or applications users (this has not been a question for SMAP)
  - **Recommendation:** ESM should establish a clear policy on this question

# Issues & Questions (2/3)

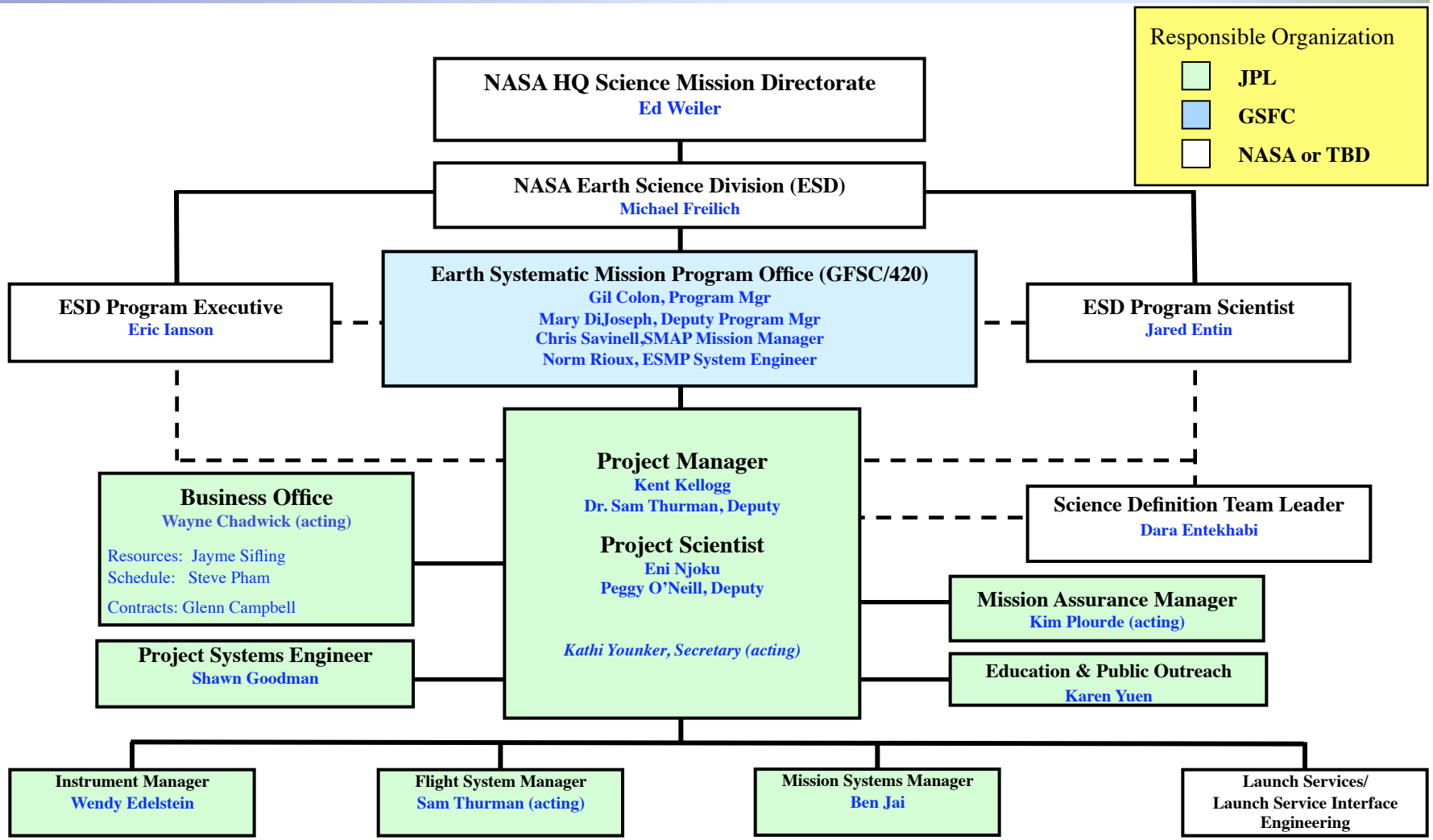
- **ESM Question:** NASA HQ, ESM Program Office and Projects need to get aligned on primary management paradigm (cost-driven, science-driven, instrument-driven, etc)
  - **Recommendation:** ESM should establish a clear policy, endorsed by ESD, on this subject to provide management guidance to its projects
  - In near term, enables Program Office to influence cost risk contained in early Project lifecycle cost estimates (rather than leaving it up to individual Project Managers and/ or their implementing institutions...)
  - In long term, establishes priority framework for PM decisions
- **ESM Issue:** GN has identified that SMAP, while within existing communication infrastructure capability, is at the current upper end of user data volume
  - Program may wish to explore communication (and networking/EDOS/SAFS) infrastructure readiness to accommodate future higher-bandwidth missions
  - Program may wish to explore funding for common infrastructure

# Issues & Questions (3/3)

- **<u>Lesson Learned:</u>** NASA Independent Review Process (IPAO) is a growing driver on Project attention and resources in early mission Phases
  - KDP-B IPAO processes and data expectations look very much like those that have traditionally been required for KDP-C
  - Rules appear to evolve rapidly (making Project planning difficult), reaching agreement on SRB Terms of Reference (ToR) has been an interminable process on SMAP (we will not likely have a signed ToR for our MDR...)
  - Funding responsibility for SRB activities should be clearly established (Project or Program responsibility)
    - Likewise implementation responsibility for SRB support contracts...
  - Current effort by NASA HQ to shorten time period between a gate review and the KDP is laudable, but may have the unintended consequence of requiring Projects to submit CADRe and other associated planning even earlier than current demands
  - **Recommendation:** ESM should join with ESD/SMD to streamline (and scale back?) this process, especially for missions in Phase A

# Backup Material

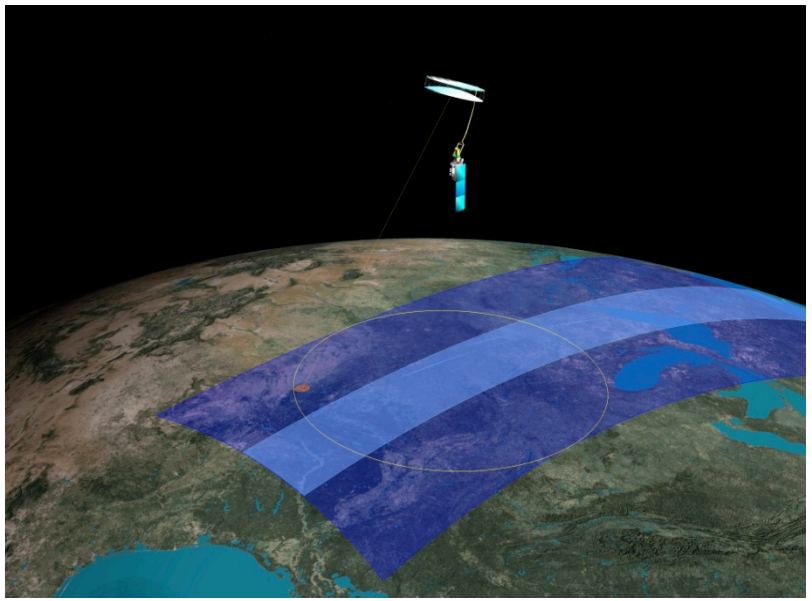
# SMAP Project Organization



# SMAP Mission Concept

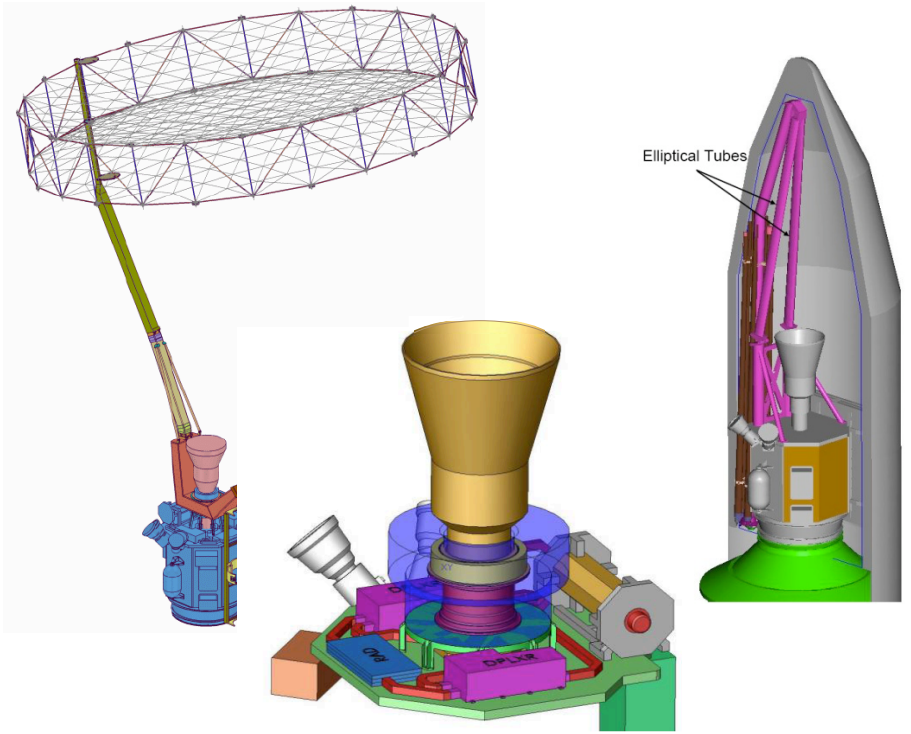
- Orbit:
  - Sun-synchronous, 6 am/pm orbit
  - 670 km altitude
- Instruments:
  - L-band (1.26 GHz) radar
    - High resolution, moderate accuracy soil moisture
    - Freeze/thaw state detection
    - SAR mode: 3 km resolution
    - Real-aperture mode: 30 x 6 km resolution
  - L-band (1.4 GHz) radiometer
    - Moderate resolution, high accuracy soil moisture
    - 40 km resolution
  - Shared instrument antenna
    - 6-m diameter deployable mesh antenna
    - Conical scan at 14.6 rpm
    - incidence angle: 40 degrees
      - Creates contiguous 1000 km swath
      - Swath and orbit enable 2-3 day revisit

- Mission Development Schedule
  - Phase A start: September 2008
  - SRR/MDR: February 2009
  - PDR: January 2010
  - CDR: December 2010
  - SIR: October 2011
  - Instrument Delivery April 2012
  - LRD: March 2013
- Mission operations duration: 3 years



# Mission Implementation Approach

- Mission partners: JPL and GSFC
  - GSFC provides radiometer, radiometer processing and science participation
  - Potential non-NASA partnerships
- Leverage knowledge from Hydros studies
- Science Team selected competitively by NASA
- Instrument lead: JPL
  - Radar provided by JPL
  - Radiometer provided by GSFC
  - Shared antenna, spin assembly procured from industry by JPL
  - Maximize Aquarius heritage
  - Capture experienced Aquarius staff
- Instrument data processing shared between JPL and GSFC




- Spacecraft developed in-house at JPL
- Launch vehicle: TBD
- Mission operations uses JPL's Earth Science Mission Operations infrastructure
  - Communications: NASA GN

National Aeronautics and Space Administration

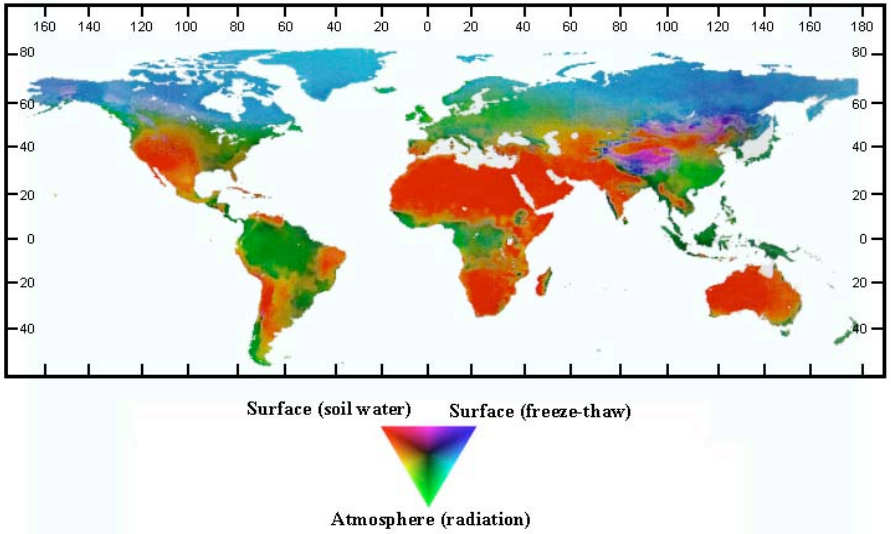
*Soil Moisture Active-Passive*

# SMAP Measures Soil Moisture and its Freeze/Thaw State

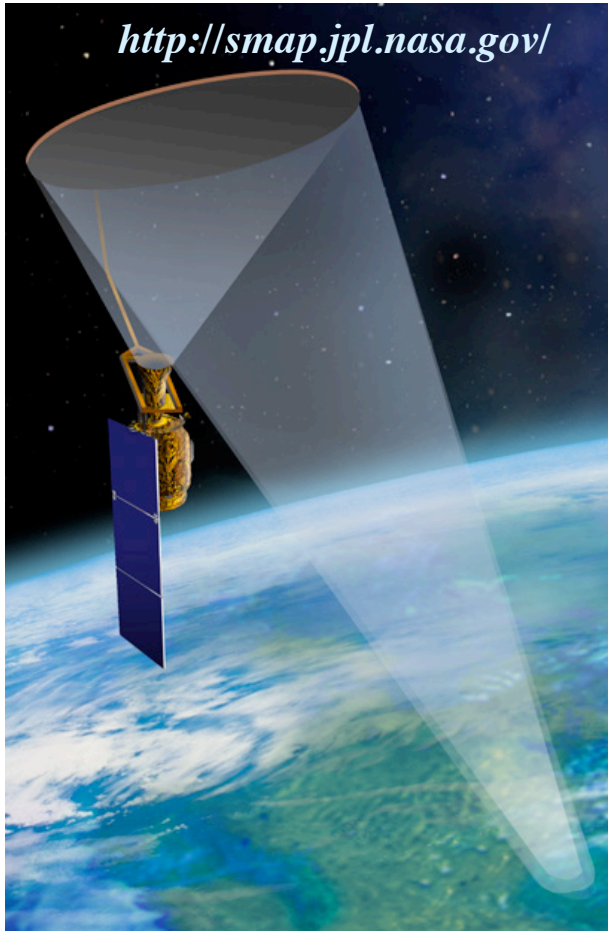
## Primary Science Objectives:

- Global, high-resolution mapping of soil moisture and its freeze/thaw state to:
  - Link terrestrial water, energy and carbon cycle processes
  - Estimate global water and energy fluxes at the land surface
  - Quantify net carbon flux in boreal landscapes
  - Extend weather and climate forecast skill
  - Develop improved flood and drought prediction capability

**Soil moisture and freeze/thaw state are primary environmental controls on Evaporation and Net Primary Productivity**



# Mission Overview




***SMAP is a first-tier mission recommended by 2007 NRC Earth Science Decadal Survey***

## Primary Science Objectives

- Global, high-resolution mapping of soil moisture and its freeze/thaw state to:
  - Link terrestrial water, energy and carbon cycle processes
  - Estimate global water and energy fluxes at the land surface
  - Quantify net carbon flux in boreal landscapes
  - Extend weather and climate forecast skill
  - Develop improved flood and drought prediction capability

## Mission Implementation:

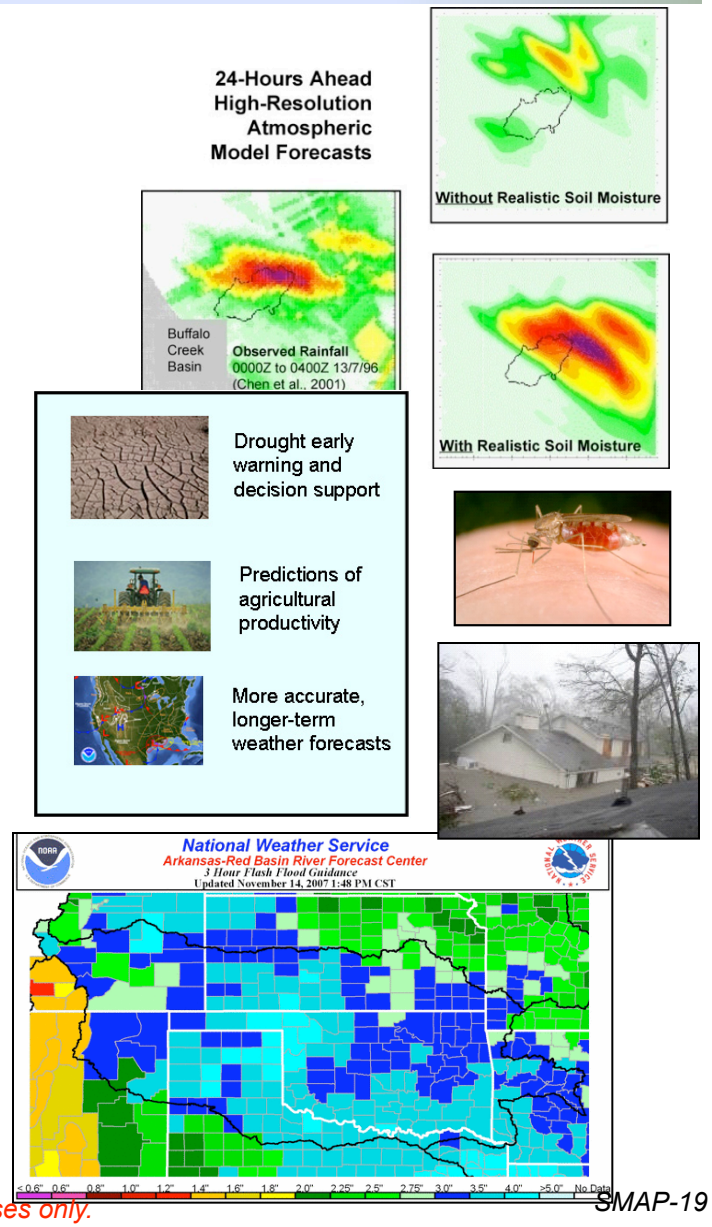
| | |
|---|---|
| Partners | • JPL (project & payload mgmt, science, spacecraft, radar, mission operations, science processing)<br>• GSFC (science, radiometer, science processing) |
| Risk | • 7120.5D Category 2; 8705.4 Payload Risk Class C |
| Launch | • March 2013, launch vehicle is TBD |
| Orbit | • Polar sun synchronous; 670 km altitude |
| Life | • 3 years |
| Payload | • L-band SAR (JPL)<br>• L-band radiometer (GSFC)<br>• Shared 6m rotating (15 rpm) antenna (JPL) |

*Soil Moisture Active-Passive*

# SMAP Science Imperative Indicated by NRC Decadal Survey

## *Four NRC Decadal Survey panels cited critical SMAP applications:*

- **Water Resources and Hydrological Cycle Panel**
  - Floods and Drought Forecasts
  - Available Water Resources Assessment
  - Linking Terrestrial Water, Energy & Carbon Cycles
- **Climate and Weather Panels**
  - Longer-Term, More Reliable Atmospheric Forecasts
- **Human Health and Security Panel**
  - Heat Stress and Drought
  - Vector-Borne and Water-Borne Infectious Disease
- **Land-Use, Ecosystems, and Biodiversity Panel**
  - Ecosystem Response (Variability and Change)
  - Agricultural and Ecosystem Productivity
  - Wild-Fires
  - Mineral Dust Production




## *SMAP is critical for improving climate and weather prediction, net carbon flux estimates, and natural hazards prediction and monitoring*